VISUAL DISPLAY UNIT ILLUMINATION

TECHNICAL FIELD

[0001] The present invention relates to a means for illuminating visual display units, particularly portable computing means including the genre known as Personal Digital Assistants (PDA).

BACKGROUND ART

[0002] The relentless tide of technological improvements in computing has inexorably led to ever more powerful computers, of ever-smaller volumes. This has given rise in recent times, to successively smaller incarnations of the Personnel Computer (PC), i.e., the desktop, laptop and notebook computer. Although of reduced physical dimensions in comparison to its predecessor, each has retained a conventional keyboard as its primary means of data input.

[0003] However, the advent of yet smaller personnel computing devices, i.e., the palmtop or Personal Digital Assistant (PDA) has precluded the use of a full-size keyboard. Furthermore, the display areas of such devices are equally restricted by their diminutive size. PDAs are typically the size of a user's hand, requiring the user interface to be designed so that input operations are not too intricate and sufficient space is available for data display. These factors are often applicable to a host of other mobile computing means such as mobile telephones, watches, calculators, data loggers, and so forth and as such these devices are included by reference herein.

[0004] These space constraints have lead to the incorporation of touchscreens as a means of combining the functions of both data entry and data display. A transflective liquid crystal display is overlaid with a transparent touch sensitive screen capable of detecting the position of a stylus point impressed upon it. The stylus may be used to select various icons and/or menus in order to issue instructions to the operating system and to input hand written data. Streamlined versions of popular spreadsheet, word processing and organisational programs are available for PDAs in addition to other specific applications designed for use within the constraints of the PDA hardware.

[0005] Most of the systems present in a conventional PC are present in a PDA. These include volatile/dynamic and permanent information storage devices or memory and a logic processor. In contrast to PCs, the operating system of a PDA is usually proprietary and stored on an on-board ROM. Subsequent user-loaded applications are stored in solid state "flash memory" rather than the rotating storage media (magnetic or optical) typically employed in PCs.

[0006] Typical PDA transflective displays consist of a birefringent liquid with a chiral additive trapped between conductive layers rubbed with a cloth or similar to align the liquid crystal molecules in a suitable manner. The birefringence of the liquid crystal may be switched to zero by applying an electric field perpendicular to the alignment layers. To achieve this one of the conductive layers is broken up into small, square or rectangular, addressable, electrodes tessellated to form a matrix while the other forms a voltage reference plane. Colour filters can be added over the electrodes to improve the effect.

[0007] This arrangement is then placed between sheets of polarising film with either aligned or perpendicular polarisation axes, located in front of a half-silvered mirror and provided with illumination. As the half-silvered mirror transmits 50% and reflects 50% of the incident light, the display can be illuminated from either side, i.e., front or back lit.

[0008] Larger, transparent liquid crystal displays (LCD) are fabricated in a similar fashion as the transflective displays with the omission of the half-silvered mirror. Backlighting is provided by cold cathode fluorescent tubes in combination with a light-guide, also known as a light pipe, and diffuser.

[0009] Prior art light pipe backlight assemblies are constructed from a light guiding panel with boundaries substantially coterminous with the LCD panel edges (normally rectangular), typically fabricated from an acrylic plastic with similar optical properties to those of borosilicate. A pair of miniature fluorescent light tubes are mounted within suitably designed light reflective mounts (i.e., located at the foci of parabolic reflectors) along the opposite side edges of the acrylic sheet.

[0010] The function of the fluorescent light tubes is to produce and direct incoherent light into the interior of the light guiding panel within which the light is typically bounded by the well known principle of "total internal reflection". Under ideal conditions, light will not leak out of the surfaces of the acrylic plastic sheet. However, light can be extracted or caused to 'leak' out from the light guide surface by forming therein scratches, undulations, or any other means of locally altering the critical angle for total internal reflection. The extracted light can be used for illumination purposes such as the above described LCD panel backlighting. A reflector is placed behind the rear surface of the light pipe to reflect rearward emitted light through the LCD, adding to the display illumination.

[0011] In order to compensate for the decrease in light guide light intensity as a function of distance from the fluorescent tubes, a light extracting pattern is permanently formed on one or both surfaces of the light guiding panel. Typically, the light extracting pattern is realised as a dot pattern permanently embossed or sandblasted upon the front surface of the acrylic light guiding panel.

[0012] In order to achieve light intensity compensation along the light guiding panel, the density of the dot pattern may be configured to increase quadratically with distance from the fluorescent light tubes. This construction provides a constant backlighting luminance across the light guiding panel. Alternative means of maintaining a uniform light emission intensity across the light guide surface is to form the panel with a tapering cross-sectional profile.

[0013] In order to integrate (ie diffuse) the spotted distribution of light emanating from the light extracting pattern towards the LCD panel, a light diffusing sheet is placed on top of the light guiding panel. The diffuser is generally a thin sheet of transparent plastic or glass material which has one surface imprinted with small ($\approx 10^{-6}$ m) humps and hollows, is placed over the face of the guide resulting in a thin, bright, uniformily lit lambertian surface. Prismatic films may be also placed between the display and the back-light to increase its efficiency.

[0014] A second light diffusing sheet is placed over the rear surface of the light guiding panel in most commercial